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(56) Documents cited
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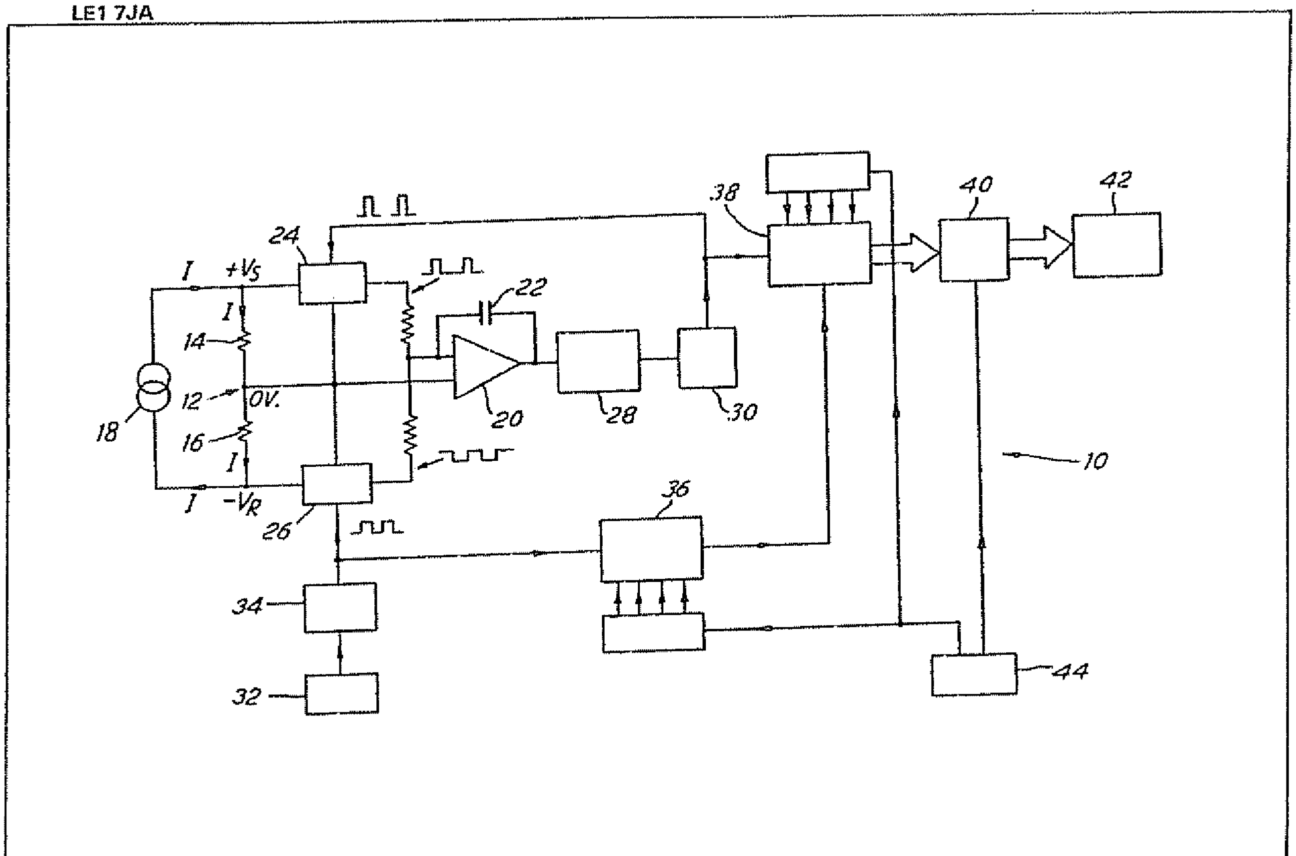
(54) Corrosion monitoring system

(57) The invention relates to a method and apparatus for monitoring the corrosion of a vessel or pipe which is exposed to a corrosive medium. A current is passed through two series resistive elements (14, 16) one of which (14) is a sample element exposed to the corrosive medium and the other of which (16) is a reference element. The two voltages generated across the respective elements are sampled and then integrated and subtracted from one another by an integrator (20). The reference element voltage is periodically sampled at a fixed sample rate and pulse width while the sample element voltage is sampled at a fixed pulse width but at a rate which varies in a manner such that the result of the subtraction of the two integrated voltages tends to zero. The frequencies of the two sampling rates are then compared to provide an indication of the degree of corrosion. The sampling frequency of the sample element voltage decreases relative to the sampling frequency of the reference element voltage as the resistance of the sample element increases with corrosion.



The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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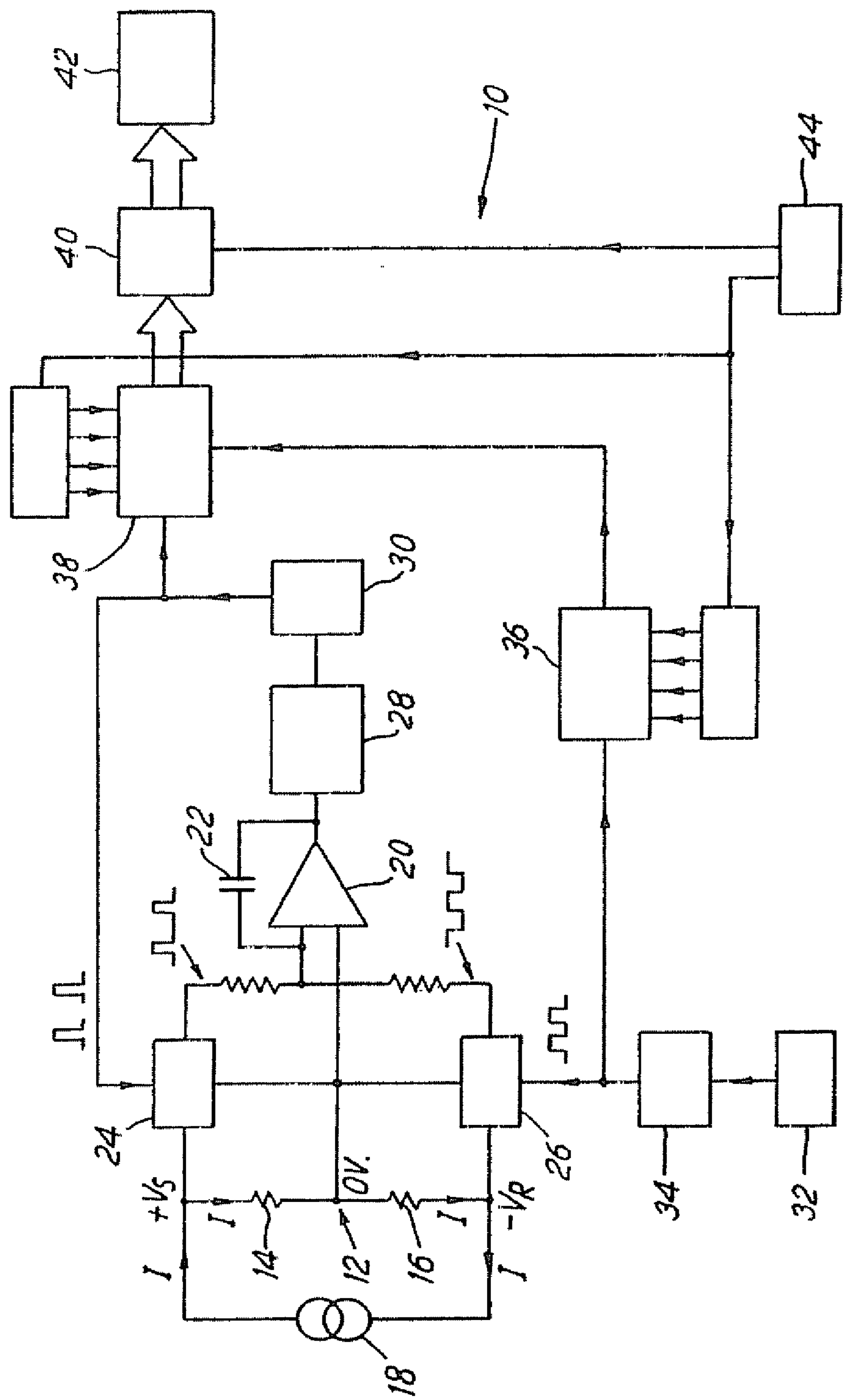

SPECIFICATION

Corrosion monitor

The present invention relates to the monitoring of corrosion, particularly the monitoring of corrosion continuously as it takes place in industrial process vessels and pipelines.

A method normally employed in monitoring the corrosion of vessels and pipes uses the so-called "sacrificial" resistance probe. This probe comprises a short length of wire or strip of a metal similar to that of the plant vessel or pipe the corrosion of which is to be monitored. Part of this wire or strip element is permanently exposed to the potentially corrosive medium in the vessel or pipe, and part is sealed to protect it from any corrosion.

The progress of corrosion is then monitored at regular intervals by measuring the ratio of the electrical resistance of the exposed ("Sample") and sealed ("Reference") elements. As the Sample element corrodes with the plant vessel or pipe and metal is lost, its resistance increases. Since both elements are at the same temperature, the effects of resistance variation with temperature are cancelled.

Most existing instruments use a bridge-balancing technique to derive corrosion readings; i.e. a current (usually A.C.) is passed through both probe elements and a bridge formed with fixed resistors and a variable resistor. The latter is manually adjusted for a null balance on a meter. Resistance ratios are chosen to produce usefully interpreted readings from a calibrated dial on the variable resistor.

The manually operated readout system while useful, has obvious limitations for automatic equipment, data logging, computer interfaced and remotely operated systems, particularly where automatic 'scanning' of a large number of probes in different plant locations is required.

The present invention provides a method for monitoring the corrosion of a vessel or pipe exposed to a corrosive medium, comprising energising a first, sample resistive element exposed to the corrosive medium and a second, reference resistive element with a d.c. signal, sampling the voltages generated across the respective elements at discrete intervals and comparing the said voltages to provide an indication of the degree of corrosion of said first element and thus of the vessel or pipe.

The present invention also provides apparatus for monitoring the corrosion of a vessel or pipe exposed to a corrosive medium, comprising a probe having a first sample resistive element for exposure to said medium and a second, reference resistive element; means for energising each said element with a d.c. signal; means for sampling at discrete intervals the voltages generated across said elements; and means for comparing the said voltages said comparison providing an indication of the degree of corrosion of said sample element and thus of the vessel or pipe.

In a preferred embodiment of the present invention, pulsed samples of the two voltages are subtracted one from the other and the frequency of the pulsed d.c. signal derived from the sample element is controlled in dependence upon the subtraction to maintain the resulting voltage at a preselected value. The variation in the frequency of the pulsed d.c. signal derived from the sample element is then a measure of the element resistance and thus its corrosion and that of the vessel or pipe being monitored.

The present invention is further described hereinafter, by way of example, with reference to the accompanying drawing which illustrates a preferred form of the present invention.

The drawing is a schematic circuit diagram of apparatus 10 which has a resistance probe 12 formed by a sample element 14 for exposure to a corrosive medium and a reference element 16. A d.c. current from a current source 18 is passed through the probe 12 to generate a respective voltage V_S and V_R across each element 14, 16 in proportion with its resistance. The junction at the elements 14 and 16 is connected to ground as is the non-inverting input of an operational amplifier connected as an integrator 20 with its output coupled to its inverting input *via* a capacitor 22. The inverting input is also connected to the ends of the elements 16, 18 remote from their junction by way of respective analogue switches 24, 26. Thus the voltages V_S and V_R are fed to the inverting input of the integrator 20 as voltages of opposing polarity. The analogue switch 24 is controlled by pulses of constant width but variable frequency while the switch 26 is controlled by pulses of constant width and frequency as is described further below.

The varying d.c. output of the integrator controls a voltage controlled oscillator 28 which triggers a monostable multivibrator 30 each cycle of its oscillatory output signal. The maximum operating frequency of the oscillator 28 is chosen such that its cycle time period is greater than the width of the pulses provided by the monostable multivibrator 30. The train of output pulses from the multivibrator 30 is fed to the analogue switch 24 to control the latter.

The output of the integrator 20 thus controls the frequency of the V_S pulses applied to its inverting input and its output signal therefore rises or falls until the average input voltage is zero, that is, the sum of the switched voltages V_S and V_R appearing at the inverting input is zero. In practice, this means that as V_S increases relative to V_R as the resistance of the sample element 14 increases with corrosion, the frequency of the output pulses of the multivibrator 30 and thus of the pulsed V_S voltage decreases. Once equilibrium is reached, the ratio of the resistances of the sample and reference elements 14, 16 is measured by measuring the ratio of the two pulse frequencies applied to the analogue switches 24 and 26, as is described below.

The switching pulses for the analogue switch 26 are derived from a fixed frequency oscillator 32 *via* a monostable multivibrator 34. The switching

pulses are also fed to a backward counter 36 which counts down one digit for each pulse applied from the multivibrator 34, from a preselected number to zero. The output of the multivibrator 30 is also fed to a second backward counter 38 which is also arranged to count down from a preselected number. The second counter 38 is enabled to begin counting by the first counter 36 on commencement of its count. Upon its reaching zero count the counter 36 inhibits the counter 38 and the count thus remaining in the counter 38 is an indication of the resistance of the sample element 14 and thus of the degree of corrosion in the plant vessel or pipe being monitored.

The count in the counter 38 is conveniently stored in a store 40 and displayed on display means 42. The display means 42 is conveniently a suitable numerical display which may be calibrated in suitable form.

A timing circuit 44 is provided to control the count and storage operations in a repetitive preset-count-store-read cycle.

CLAIMS

1. A method for monitoring the corrosion of a vessel or pipe exposed to a corrosive medium, comprising passing a current through a first resistive element exposed to the corrosive medium and a second reference resistive element to generate respective first and second voltages across said elements, periodically sampling said voltages and comparing said sampled voltages to provide a signal indicative of the degree of corrosion of said first element and thus of the vessel or pipe.

2. A method as claimed in claim 1 wherein said sampled first and second voltages are integrated and compared and the sampling rate of said first voltage is controlled by said signal to adjust the integrated value of said sampled first voltage towards a preselected value.

3. A method as claimed in claim 2 wherein said preselected value is the integrated value of said sampled second voltage.

4. A method as claimed in claim 2 or 3 wherein said signal is a pulse train of constant pulse width whose frequency varies in dependence on the comparison of said sampled voltages.

5. A method as claimed in claim 5 comprising counting the number of pulses of said pulse train occurring over a preselected time period and comparing said count number with a reference number to provide said indication of the degree of corrosion.

6. Apparatus for monitoring the corrosion of a vessel or pipe exposed to a corrosive medium, comprising a probe having a first sample resistive element for exposure to said medium and a second, reference resistive element; first means for passing a current through said first and second elements to generate respective first and second voltages across said elements; and second means coupled to said elements and operable to comparing said voltages and to provide in dependence on said comparison a signal indicative of the degree of corrosion of said sample element and thus of the vessel or pipe.

7. Apparatus as claimed in claim 6 wherein said second means comprises respective first and second sampling circuits for periodically sampling said first and second voltages and a comparator for integrating and comparing said sampled first and second voltages.

8. Apparatus as claimed in claim 7 wherein said comparator is operably coupled to said first sampling circuit for controlling the sampling rate of said first voltage in dependence on said comparison to adjust the integrated value of said sampled first voltage towards a preset value.

9. Apparatus as claimed in claim 8 wherein said preset value is the integrated value of said sampled second voltage.

10. Apparatus as claimed in claim 7, 8 or 9 further comprising a first pulse generator coupling said comparator to said first sampling circuit and operable to apply to said first sampling circuit for controlling the sampling rate thereof a first pulse train of constant pulse width whose frequency varies in dependence on the comparison of said voltages; and a second pulse generator coupled to said second sampling circuit for applying thereto a second pulse train of constant pulse width and frequency.

11. Apparatus as claimed in claim 10 wherein said first pulse generator comprises a voltage controlled oscillator and a monostable multivibrator triggerable by each cycle of said oscillator.

12. Apparatus as claimed in claims 10 or 11 further comprising comparator means for comparing the frequency of said first and second pulse trains and a display means for displaying the result of said comparison.

13. Apparatus as claimed in claim 12 wherein said comparator means comprises first and second backward counters coupled for receiving the respective first and second pulse trains and operable to count down from respective preselected count values at a countdown rate determined by the frequency of the received pulse train, and a control circuit operable to set said counters at their respective preselected count values and initiate countdown of said counters, and wherein said first counter is inhibited responsively to said second counter counting down to a further preselected value and said display means is operable to display a value representative of the count value remaining in said first counter.

14. Apparatus as claimed in claim 13 wherein said control circuit comprises a preset select circuit for setting the respective preselected count values in said counters and a timing circuit for periodically initiating said countdown.

15. Apparatus as claimed in claim 13 or 14 further comprising a store coupling said first counter to said display means and controlled by said control circuit for storing said remaining count prior to display of said representative value.

16. Apparatus as claimed in claims 13, 14 or 15 wherein said further preselected count is zero.

17. Apparatus as claimed in any of claims 13 to 16 wherein said first counter is enabled to commence counting by said second counter responsively to said second counter commencing its count.

18. Apparatus for monitoring the corrosion of a vessel or pipe exposed to a corrosive medium, substantially as hereinbefore described with reference to the accompanying drawing.

19. A method for monitoring the corrosion of a vessel or pipe exposed to a corrosive medium, substantially as hereinbefore described with reference to the accompanying drawing.

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